

DECUS NO.

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TITLE

TELETYPE INPUT-OUTPUT PACKAGE

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DATE

December 9, 1969

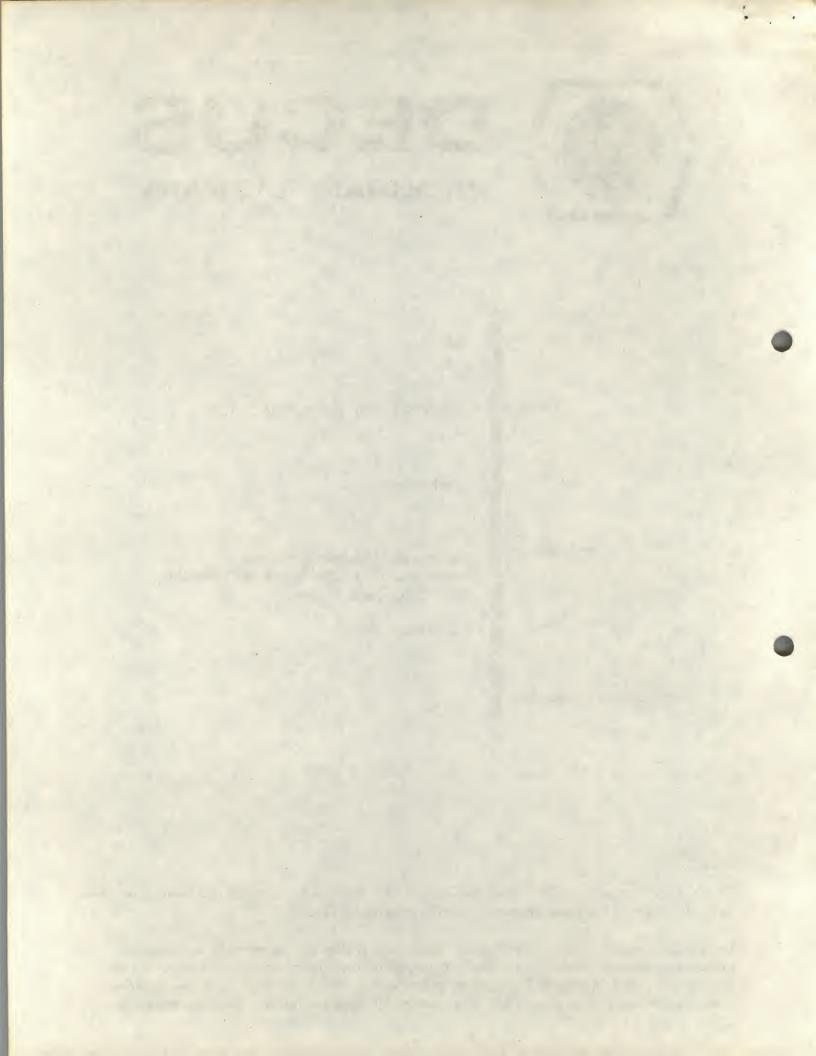
SOURCE LANGUAGE

PAL-D

ATTENTION

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Title: Teletype Input-Output Package

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Date: 2 December 1969

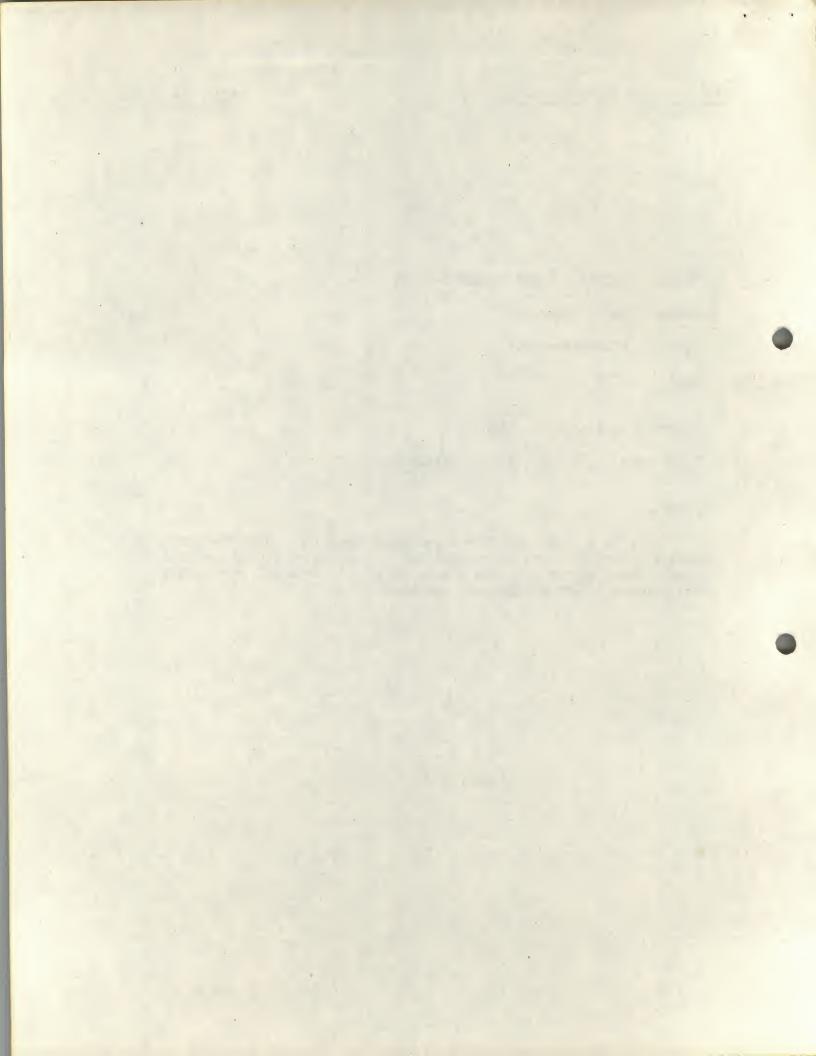
Name: TTYP

Programming language: PALD

Core usage: One page, plus location 0.

Abstract:

This is a teletype control package containing subroutines for single-character input and output and for output of packed and open text. These subroutines are single-field oriented, but provide for interrupt-enabled and disabled operation.



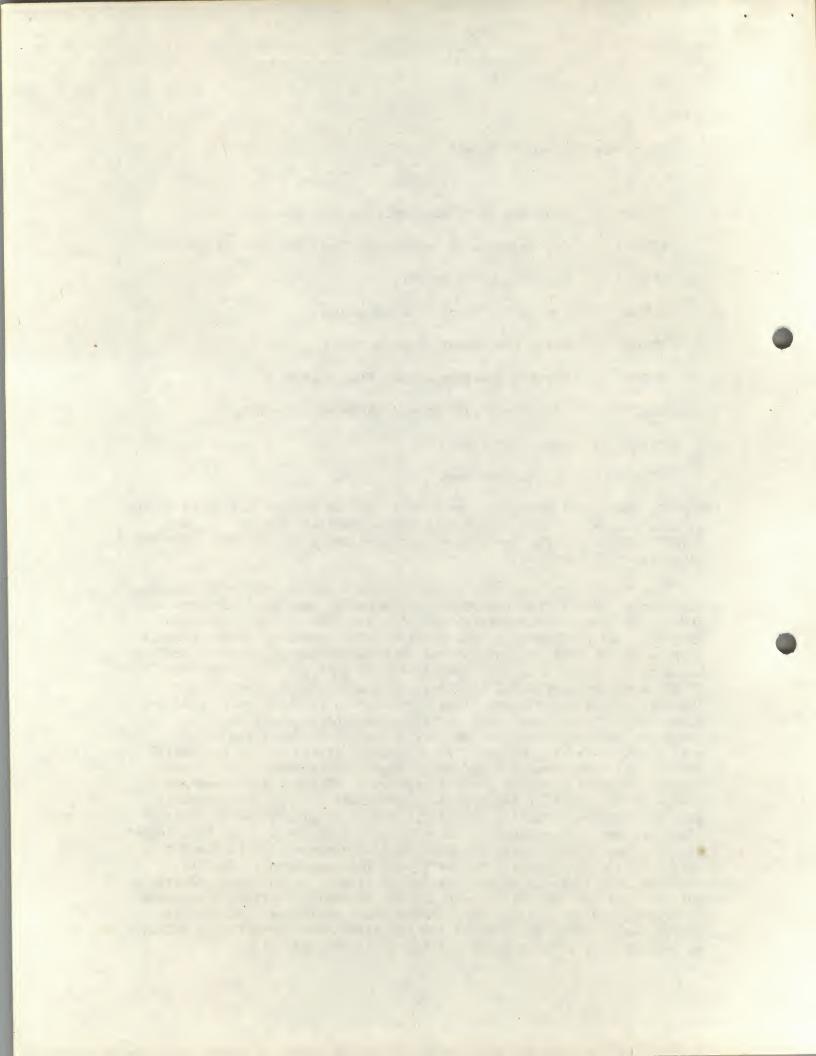
Description:

There are nine subroutines:

Name	Function		
KTREAD	Read one input character unconditionally.		
KTGET Get contents of keyboard buffer (conditional input			
KTKCL	KTKCL Clear keyboard buffer.		
KTKSV	KSV Service keyboard flag interrupt.		
KTWRTE	Write one output character.		
KTTSV	Service teletype output flag interrupt.		
KTACPT	Accept keyboard input character and echo it.		
TYPOPN	Type open text.		
TYPPAK	Type packed text.		

KTREAD, KTGET, and KTACPT return to the calling program with data in the accumulator; all others return with the accumulator cleared to zero. KTWRTE takes data from the accumulator upon entry; all others clear the accumulator at the start.

The design of these subroutines is based on the following interrupt philosophy: Under interrupt-disabled operation the user's program consists of a single process which includes all calculations, decision branches, and peripheral device service. The operation of peripherals simultaneously with one another and with the calculating and branching parts of the program is thus limited to the inherent buffering capabilities of the peripheral hardware. Under interrupt-enabled operation the user's program contains first a main process, which makes calculations and decisions and which initiates peripheral operations, and second an interrupt service process, which clears flags and issues such commands as are required by the current states of the peripheral devices [8]. Whenever the interrupt service determines that no more devices currently require service, execution of the main process must resume at the point of interruption. The main process runs primarily with the interrupt facility enabled but with it disabled when instructions are executed which are common to both processes. Thus this teletype package is unsuitable for time-sharing systems, but it can run only one teletype anyway. Interrupt-enabled operation is made to resemble interrupt-disabled operation as closely as possible; therefore buffering of the teletype is actually or virtually limited to hardware buffering, and multiple entry points for the individual subroutines are avoided. Other peripherals can run simultaneously with the teletype as permitted by program logic and the interrupt facility.



If the calling program enables the interrupt facility, the interrupt flag identification routine should contain some coding sequence such as:

KSF

JMS KTKSV

TSF

SKP

JMS KTTSV

KTKSV and KTTSV should be called only while the interrupt facility is disabled and only in response to interrupts. No references in the calling program to these two subroutines are needed if the interrupt facility is always disabled. All the remaining subroutines may be called with the interrupt facility enabled or disabled, but only as part of the main process.

The text output subroutines have calling sequences as follows:

JMS TYPOPN AREA

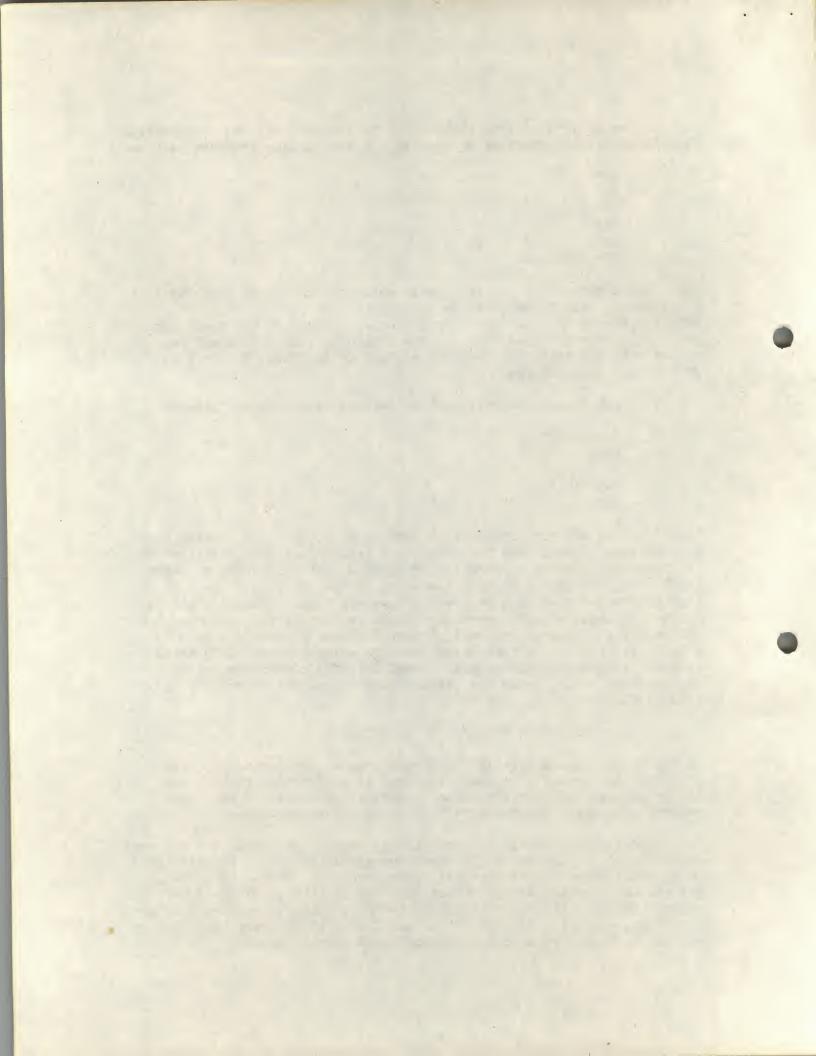
JMS TYPPAK AREA

"AREA" is the address of the first word of the text. The separation of the character string from the subroutine call allows more efficient use of PDP-8 memory pages. TYPOPN outputs open text consisting of 8-bit ASCII with one right-justified character per memory word. The text string is terminated by a zero word; however, blank tape can still be punched by means of a non-zero word which is zero in the low-order 8 bits. When writing a program, certain characters, such as carriage return, line feed, rubout, and back arrow, must be written in octal to avoid problems with the Editor program. Most printing characters can be written explicitly, using the single-character assembly facility of PALD or MACRO-8 [2,5]. For example:

MESG, 215;212;"M;"E;"S;"S;"A;"G;"E;0

At least three characters in the source program are needed for each character in the text, so that open text is inefficient in both the source program and object program. However, open text is more convenient as program-generated text, such as numerical output.

TYPPAK outputs 6-bit stripped ASCII, packed two characters per word, as assembled by PALD or MACRO-8 when the pseudo-op "TEXT" is used [3,6]. Permissible output characters are space, carriage return, line feed, and all the graphics except the at (0), per cent (%), and pound (#) signs. The text is terminated by 00 (octal), which is generated by the assembler, and which is what "0" in the text will compress to. The at sign is therefore a logical choice for a text delimiter. The



per cent and pound signs are compressed in the usual way by the assembler but then converted by TYPPAK to carriage return and line feed respectively [1]. The back arrow is excluded by the Editor, rather than by TYPPAK or the assembler. In addition, if the Editor converts successive spaces in the text to a single tabulate character, the final result in the output will be "I".

Both text subroutines call KTWRTE, which the calling program may also access directly. KTWRTE loops until the teletype flag rises, or until enough time has elapsed to assure that no flag is pending, and then issues the output command [7]. The entry point KTWRTE is immediatedly followed by a skip and return:

KTWRTE, 00 SKP JMP I KTWRTE

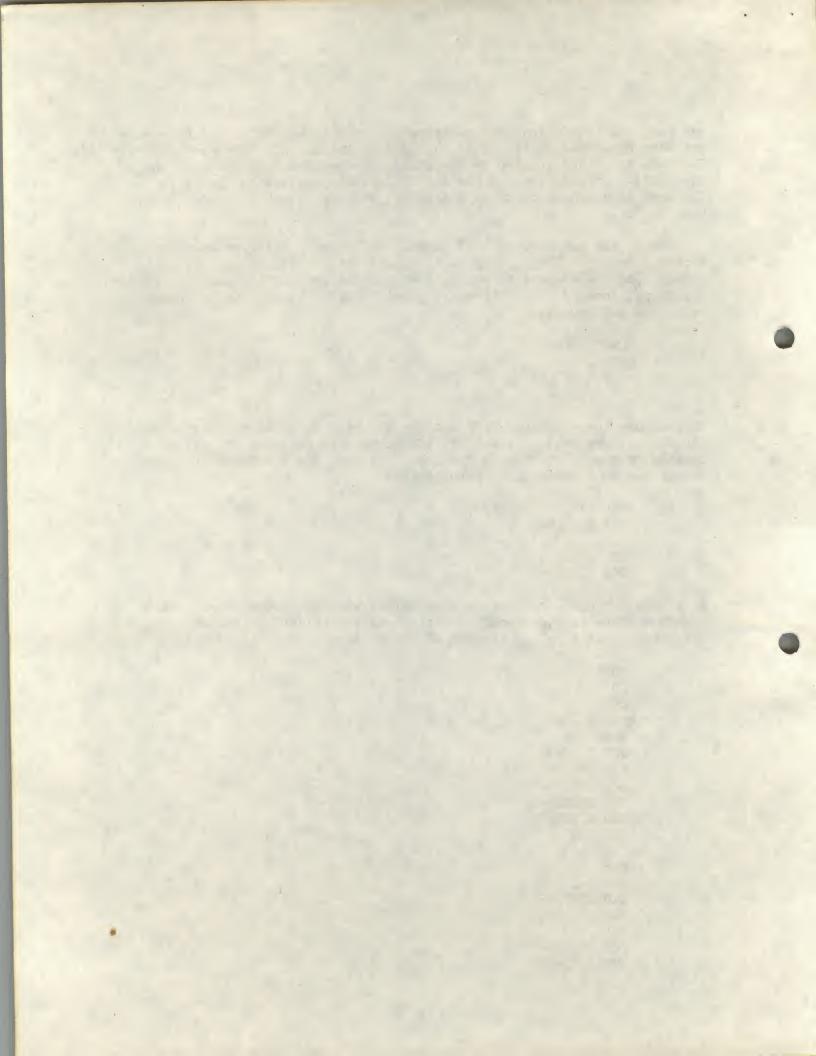
This allows the output of TYPPAK to be diverted to another device when the skip is replaced by a call to the subroutine for that device. For example, suppose "PTWRTE" is the name of a fast punch subroutine. Then output can be diverted and restored thus:

TAD (JMS I [PTWRTE])
DCA KTWRTE+1

TAD (SKP)
DCA KTWRTE+1

Note that "PTWRTE" must return to KTWRTE+2 with the accumulator cleared. KTWRTE must be in its normal condition whenever KTACPT is called. For the PDP-8/5 the supplied version of KTWRTE should be replaced by:

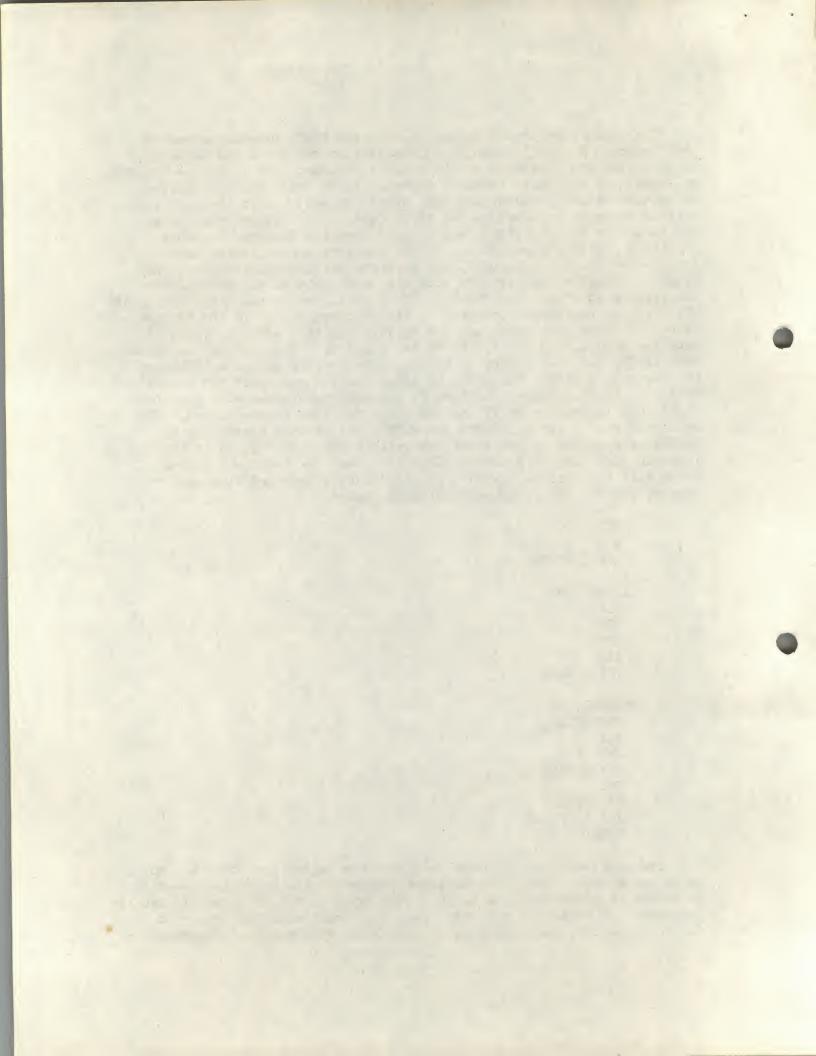
00 00 00 KTWRTE, 00 SKP JMP I KTWRTE DCA KTWRTE-2 DCA KTWRTE-3 ISZ KTWRTE-3 TAD KTWRTE-1 SNA CLA JMP .+3 TSF JMP .-5 TAD KTWRTE-2 TLS STA DCA KTWRTE-1 JMP I KTWRTE



The input subroutines KTREAD, KTGET, and KTKCL provide access to the "keyboard buffer," which is an abstraction but which has these properties from the viewpoint of the calling program: The buffer is cleared, or voided, by a program command; keyboard input data loads the buffer, which then remains loaded with this input character until cleared by the program or until reloaded by new input data. KTKCL clears the buffer and should be called before data is read from the teletype to avoid inputting spurious characters. KTREAD provides unconditional input; after entry KTREAD loops until the keyboard buffer contains data, then clears the buffer, and returns with the input data in the accumulator and also in core location KTNEXT. KTGET is a conditional input subroutine which shows the current contents of the keyboard buffer in the accumulator but which does not clear the buffer. If the buffer is void, it sets the accumulator to -1. KTGET is called by KTREAD and may be called directly by the user's program to determine whether or not a teletype key has been pressed. In order to determine the status of the interrupt facility, KTGET accesses location 0; the calling program must therefore avoid this location even if the interrupt facility is never used. The interrelation of KTKCL, KTGET, and KTREAD may be made clearer by the following examples of how these subroutines would be written if the interrupt facility were always disabled. Here the "keyboard buffer" is in fact the hardware buffer, provided that a keyboard flag must be present for the buffer to be considered loaded.

> KTKCL, 00 KCC JMP I KTKCL KTGET, 00 CLA KRS KSF STA JMP I KTGET KTREAD, 00 JMS KTGET SPA JMP .-2 DCA KTNEXT KCC TAD KTNEXT JMP I KTREAD KTNEXT, 00

Interrupt-enabled operation and teletype paper tape input are not fully compatible. This is a hardware characteristic and cannot readily be offset in programming; a fairly large input buffer in memory is usually required. If KTREAD is used for paper tape input with the interrupt facility enabled, successive calls must occur within 100 milliseconds



to avoid loss of data; if the teletype reader is ready, the tape will advance continuously even when input is not requested. Under interrupt-disabled operation the tape advances by one character for each call to KTREAD.

KTACPT inputs characters from the keyboard and echoes them on the teleprinter. It first clears the keyboard buffer, then reads one character, echoes it, and returns with the character in the accumulator and in KTNEXT. All characters are typed as read except carriage return, which is echoed as carriage return plus line feed. KTACPT is not suitable for paper tape input because of this double echo and because KTKCL should be called only once at the beginning of a paper tape, not repeatedly while the tape is read. Paper tape input with teletype echo is performed by this coding sequence:

JMS KTREAD JMS KTWRTE TAD KTNEXT

This teletype control package is intended for use by programs which run entirely within 4096 words of memory or which use extended memory only as fast-access auxiliary data storage. Its use on a multiple-field PDP-8 is subject to these restrictions: Each subroutine must be called with the data field matching the instruction field, and it will return only to locations in the field where it resides. Location 0 must be avoided in any field where KTGET is called. Interrupt-enabled operation is limited to field 0. Text for TYPOPN or TYPPAK must not "wrap around" from location 7777 to location 0.

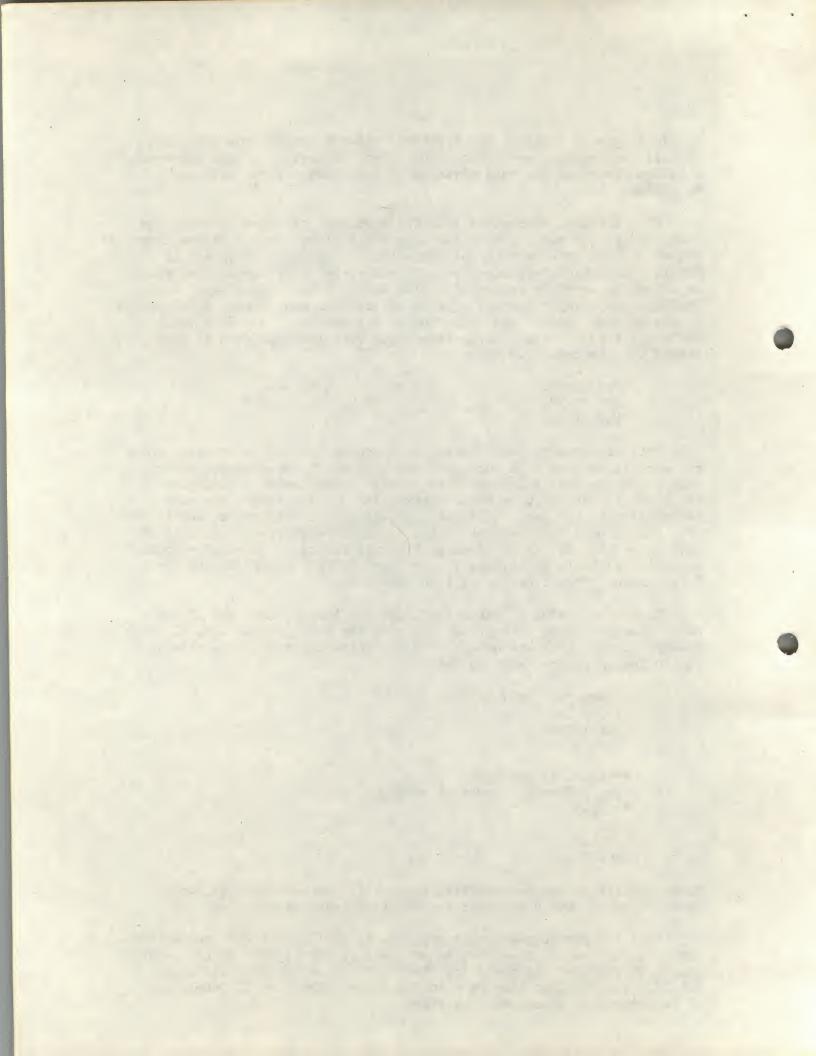
It can be useful to patch the input and output functions of the PDP-8 floating-point interpreter [4] into the teletype package, allowing floating-point input and output with the interrupt facility enabled. The following patches will do this:

*7344+1 /OUTPUT PATCH JMS I .+2 JMP I 7344 KTWRTE

*7142+1 /INPUT PATCH
JMS I [KTKCL] /OMIT IF PT INPUT
*7142+2
SKP
KTREAD
JMS I .-1

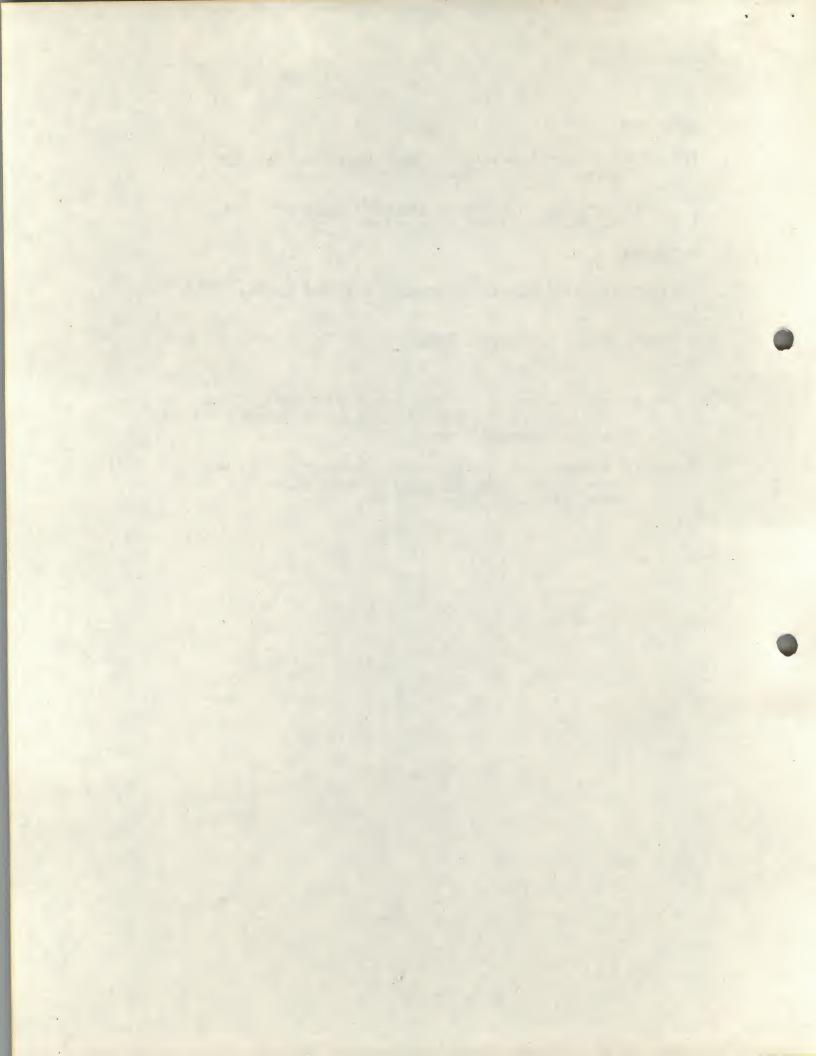
These patches should be assembled along with the main program, which must be loaded into core after the floating-point interpreter.

This subroutine package is supplied in ASCII, both with and without comments, and can be assembled as one page of core in the user's program. The first line has the pseudo-op "PAGE", which is the only exception to PAL III, and the last line is a dollar sign. There are 11 labels and no references to auto-index registers.



References:

- 1. Digital Equipment Corporation, Alphanumeric Message Typeout, Digital-8-18-Sym, February 16, 1967.
- 2. idem, PAL-D Disk Assembler Programmer's Reference Manual, DEC-D8-ASAA-D, April 1968, p. 1-12.
- 3. ibidem, p. 2-2.
- 4. idem, PDP-8 Floating-Point System Programming Manual, DEC-08-YQYA-D, 1968.
- 5. idem, MACRO-8 Programming Manual, DEC-08-CMAA-D, 1965, p. 5-12.
- 6. ibidem, pp. 6-3, 6-4.
- 7. Fichtenbaum, Matthew L., to Mrs. Angela J. Cossette (DECUS Executive Secretary), June 7, 1967, distributed to members of Digital Equipment Computer Users Society.
- 8. Wirth, Niklaus, "On Multiprogramming, Machine Coding, and Computer Organization," Communications of the ACM, vol. 12, no. 9 (Sept. 1969), pp. 489-498.



PAGE 1 13670

// JOB T 0002 0002 13670

LOG DRIVE CART SPEC CART AVAIL PHY DRIVE 0000 0001 0001 0000 0001 0002 0002 0001

V2M6 16K SDSMT COMP CNTR 05DEC69

// * GARTH PETERSON 50120

· // XEQ PTTCD

KTACPT 0274
KTGET 0213
KTKCL 0225
KTKSV 0232
KTNEXT 0211
KTPA 0351
KTREAD 0200
KTTSV 0265
KTWRTE 0242
TYPOPN 0311
TYPPAK 0325

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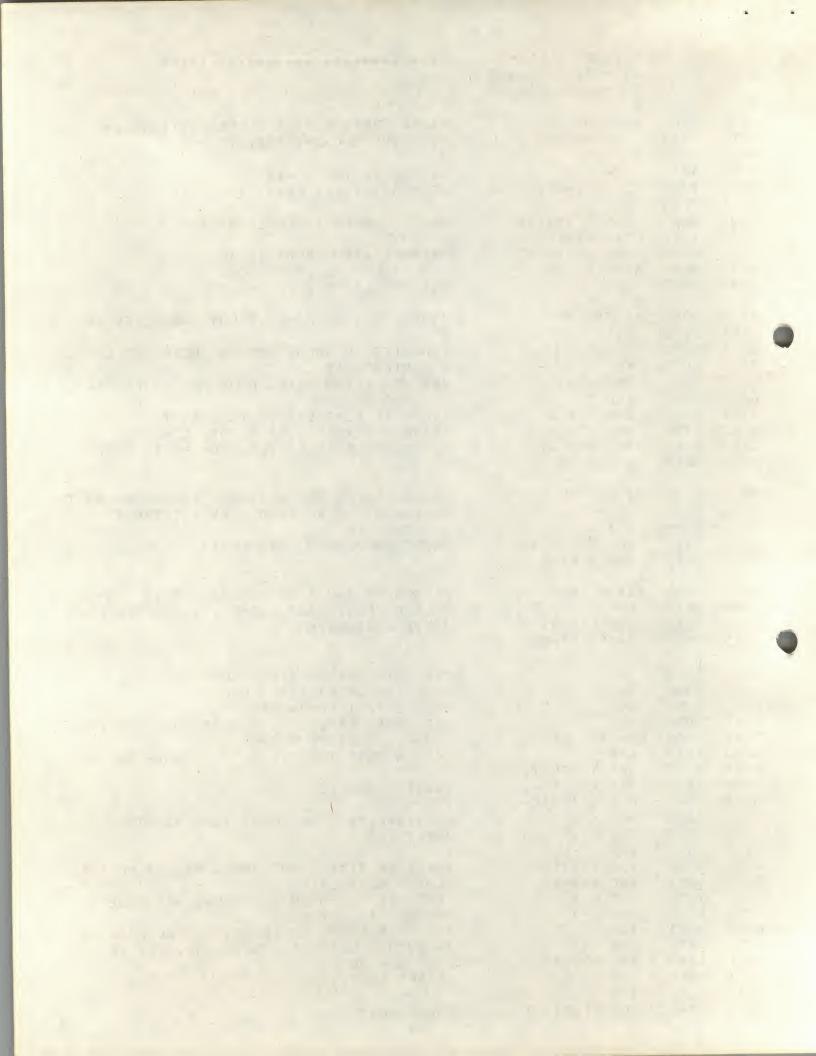
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PAGE
                                 /*****************
            /TTY I/O PACKAGE
            /11MR68, 30NV69
0200 0000
           KTREAD, 00
JMS KTGET
                               /SUBR, READ KEYBOARD UNCONDITIONALLY
0201
      4213
                                /GET INPUT CHARACTER, IF ANY
0202
     7510
             SPA
0203
             JMP .-2
     5201
                                /IF NONE, TRY AGAIN
     3211
0204
             DCA KTNEXT
                                /DEPOSIT INPUT CHARACTER
0205
      7240 STA
0206
     3212 DCA KTNEXT+1
                               /MARK BUFFER IN CORE EMPTY
     1211 TAD KTNEXT
5600 JMP I KTRE
0207
             JMP I KTREAD
0210
                             /RETURN WITH INPUT IN AC
/+O TELETYPE INPUT WORD
0211
     0000
            KTNEXT, 00
0212
     0000
             00
                               /+1
                                     TELETYPE INPUT BUFFER
0213
     0000
                              /SUBR, GET TELETYPE INPUT CHARACTER IF
            KTGET, 00
0214
     7200
             CLA
                                / ANY
0215
     3000
             DCA O
                              /LOCATION O HOLDS RETURN ADDRESSES OF
                              / INTERRUPTS
0216
     6031 KSF
     5223 JMP .+4
1000 TAD 0
0217
                                /BRANCH IF NO FLAG, LOOK FOR CHARACTER
0220
                             / IN CORE
/SKIP IF FLAG CAUSED INTERRUPT
      7650 SNA CLA
0221
           JMS KTKSV
0222 4232
                               /READ HARDWARE BUFFER INTO CORE
            TAD KTNEXT+1
0223 1212
                               /GET BUFFER CHARACTER, AC= -1 IF NONE
0224 5613
            JMP I KTGET
0225 0000 KTKCL, 00
                               /SUBR, CLEAR OUT PREVIOUS KEYBOARD INPUT
0226 6032
            KCC
                                /CLEAR HARDWARE FLAG WHEN INTERRUPT
0227 7240
             STA
                               / DISABLED
0230 3212
             DCA KTNEXT+1
                               /MARK BUFFER IN CORE EMPTY
0231 5625
             JMP I KTKCL
0232 0000
           KTKSV, 00
                               /KEYBOARD INPUT INTERRUPT & FLAG SERVICE
0233 6036
             KRB
                                /CLEAR FLAG, READ BUFFER, ALLOW NEW CHAR
0234
      3212
             DCA KTNEXT+1
                                /SAVE CHARACTER
0235
      5632
             JMP I KTKSV
0236 0000
             00
                               /-4 HIGH-ORDER TIME COUNT
0237
     0000
             00
                               /-3 LOW-ORDER TIME COUNT
0240 0000
                                1-2 OUTPUT CHARACTER
             00
0241 0000
                              /-1
             00
                                     BUSY LATCH, -1 = BUSY, 0 = NOT BUSY
0242 0000
            KTWRTE, 00
                               /SUBR, TELETYPE OUTPUT
0243 7410
           SKP
                                /PATCH HERE TO DIVERT TO ANOTHER DEVICE
0244 5642
             JMP I KTWRTE
0245 3240 DCA KTWRTE-2
                                /SAVE CHARACTER
0246 7346
           CLL STA RTL
                               /AC = -3
0247 3236
            DCA KTWRTE-4
                               /INITIALIZE TIME COUNT (140 MS MIN)
0250 2237
            ISZ KTWRTE-3
                               /BEGIN LOOP
0251
     7410
            SKP
0252 2236
            ISZ KTWRTE-4
                               /SKIP IF TIME COUNT DONE, EXPECT NO FLAG
0253 1241
            TAD KTWRTE-1
                                /CHECK BUSY LATCH
0254 7650
            SNA CLA
                                /SKIP IF LATCH ON AND COUNT NOT DONE
                            /BRANCH IF NOT BUSY
/SKIP IF FLAG, INTERRUPT MAY BE DISABLED
/PREVIOUS CHARACTER NOT DONE, TRY AGAIN
0255 5260
            JMP .+3
0256 6041
            TSF
            TSF
JMP .-7
TAD KTWRTE-2
0257 5250
                             /GET CHARACTER
0260 1240
0261 6046
            TLS
                               /START TELETYPE
0262 7240
            STA
0263 3241
            DCA KTWRTE-1
                              /MARK BUSY
```

9



```
0264 5642
            JMP I KTWRTE
 0265
      0000
            KTTSV, 00
                                /TELETYPE OUTPUT INTERRUPT SERVICE
 0266
      6042
             TCF
                               /CLEAR FLAG
 0267
      7200
             CLA
 0270
      3241
             DCA KTWRTE-1
                                /MARK NOT BUSY
 0271
      5665
             JMP I KTTSV
 0272
      0212
            212
 0273
     7563
            -215
 0274
      0000 KTACPT, 00
                                /ACCEPT (AND ECHO) KEYBOARD INPUT
 0275
     4225 JMS KTKCL
                               /CLEAR KEYBOARD BUFFER
 0276
     4200 JMS KTREAD
                               /READ KEYBOARD
 0277
     4242
            JMS KTWRTE
                               /ECHO ON TELEPRINTER
     1211 TAD KTNEXT
0300
     1273 TAD KTACPT-1
0301
                            /CHECK FOR CARRIAGE RETURN
0302 7640 SZA CLA
0303 5306 JMP .+3
0304 1272 TAD KTACPT-2
                               /IF CARRIAGE RETURN, SUPPLY LINE FEED
0305
     4242
             JMS KTWRTE
0306
     1211
            TAD KTNEXT
                               /GET CHARACTER
0307
      5674
             JMP I KTACPT
                               /RETURN
0310
     0000
            00
0311
      0000
            TYPOPN, 00
                              /TYPE MESSAGE OF OPEN TEXT
0312
      7200 CLA
                               1
                                    JMS TYPOPN (EFFECTIVE)
0313
     1711
            TAD I TYPOPN
                              1
                                    ADDRESS-OF-MESSAGE
                              / (NEXT INSTRUCTION)
0314
     3310 DCA TYPOPN-1
0315
     2311 ISZ TYPOPN
0316 1710 TAD I TYPOPN-1
0317
      2310 ISZ TYPOPN-1
0320
      7450 SNA
0321 5711
          JMP I TYPOPN
                              /ZERO WORD TERMINATES MESSAGE
0322 4242
             JMS KTWRTE
                              /WRITE CHARACTER
0323 5316
             JMP .-5
0324 0000
           00
                          / TEXT POINTER /TYPE PACKED TEXT
           TYPPAK, 00
0325 0000
0326
     7200
           CLA
                              1
                                    JMS TYPPAK (EFFECTIVE)
0327
           TAD I TYPPAK
     1725
                                    AREA
0330 3324
            DCA TYPPAK-1
                              /
                                   (NEXT INSTRUCTION)
0331 2325
            ISZ TYPPAK
           TAD I TYPPAK-1 /GET FIRST CHAR IN WORD
0332 1724
0333 4351
            JMS KTPA
0334 1724
            TAD I TYPPAK-1 /GET SECOND CHAR IN WORD
0335
     7006
            RTL
0336 7006
            RTL
                               /LEFT-JUSTIFY
0337
     7006
            RTL
0340 4351
            JMS KTPA
0341
     2324
          ISZ TYPPAK-1
                               /INCREMENT POINTER
0342 5332
            JMP TYPPAK+5
0343
    0245
            245
                              /PER CENT
0344
     7750
            215-245
                               /CR - PER CENT
0345
     7776 243-245
                              /POUND - PER CENT
     7747
0346
          212-243
                              /LF - POUND
0347
     7535
            -243
                              / -POUND
0350
     7700
            7700
0351 0000 KTPA, 00
                              /SUBR, PRINT 6-BIT ASCII LEFT
0352 0350
          AND KTPA-1
                              /CLEAR RIGHT 6 BITS
0353
     7450
            SNA
```

0354 0355 0356	5725 7101 7500	JMP I TYPPAK CLL IAC SMA	/RETURN IF OO CHAR (NO AT SIGN) /AC BIT 11 WILL GO TO CHANNEL 8
0357	7120	STL	/LINK WILL GO TO CH 7 (= COMPLEMENT OF
0360	7012	RTR	/AC 0-5 GO TO CHS 6-1
0361	7012	RTR	
0362	7012	RTR	/AC HOLDS 8-BIT ASCII
0363	1347	TAD KTPA-2	
0364	7450	SNA	
0366	1346	TAD KTPA-3	/CHANGE POUND SIGN TO LINE FEED
0367	1345 7450	TAD KTPA-4	
0370	1344	SNA	
0371	1343	TAD KTPA-5	/CHANGE PER CENT TO CARRIAGE RETURN
0372	4242	TAD KTPA-6 JMS KTWRTE	
0373	5751	JMP I KTPA	/WRITE CHARACTER
0019	2131		
		/END, TTY PKG	*******

